1 Introduction

The European project Womeng (“Creating Cultures of Success for Women Engineers”) focuses first female engineering students, their reasons for choices at key stages of decision (work package 2) and their motivation and attitudes toward retaining (satisfaction) or leaving (drop out) (work package 3).

Another perspective is to look at organizational culture and focus on conditions that influence choice, success and persistence from the point of view of institutions (work package 4). Hopefully, analysing the results allows a comparison between women friendly and traditional masculine institutional characteristics at first glance. The project is designed in two phases, of which the first will concentrate on higher education and the second will focus on professional sphere.

This paper will describe the approach for measuring the organisational culture and analyse conditions and possibilities for change. The main focus therefore is workpackage 4 of Womeng, which aims at identifying gendered institutional cultures and structures in higher education. After a short description of state of the art, hypotheses and methodological approach different gender theories focus on understanding and changing masculine organisational structures of engineering educational institutions.

2 State of the Art

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1 The European project Womeng started in November 2002 and will last until October 2005. It is divided in 6 work packages. Looking for more persistence of women engineers in higher education and employment one can first distinguish key stages of choice of women for describing, analysing and changing factors (work package 2). The next research step will be to distinguish positive and negative results in making choices out of point of view of women (work package 3). Another perspective is to look at organizational culture (conditions) that influence choice, success and persistence out of point of view of institutions (work package 4). Other parts of the projects are investigating appropriate cross-cultural methodology for gender studies (work package 1), and dealing with dissemination, exploitation and coordination of the project (work packages 5 and 6).
Many efforts have been made to change societal gender segregation in higher education and professional sphere. Introducing gender mainstreaming in Europe has brought forward several political and research initiatives. ETAN group has presented rich material – statistical and qualitative – about status quo for women in science and engineering in Europe, and at the same time recommended what should be investigated in the future (ETAN 2000). Likewise in all European countries there exist national reports and empirical studies on engineering. The report points out that in all EU Member States women are under-represented in mathematics and computer science as well as in engineering and architecture (except Germany). Girls seem to prefer sciences linked to nature, human and social matters (European Commission 2000:58).

Studies in European and non European countries have shown that what drives women away from technology are not women’s deficits in abstract thinking, etc. but the content and climate prevalent in technical institutions, which construct an atmosphere of “dominant masculinity“ (Hoeborn 1990; Kahlert/Mischau 2000; McLean et al.; Metz-Göckel/Schmalhaf-Larsen 2000; Roloff 1989; Sagebiel 1988; Vogel/Hinz 2000; Schwarze/Webler 1998). Therefore universities and other training institutions have started to improve curricula, thus making both climate and content of teaching appropriate to attract and retain both, men and women.

2.1 European Research on Women and Engineering

In recent years a number of quantitative (Blättel-Mink 2000a and 2000b) and qualitative (Collmer 1997; Erb 1996; Janshen/Rudolph 1987; Kossbiel/Bammé/Martens 1987; Michel 1996; Stadler 1997; Wächter 2001; Wolffram 2000) studies have been carried out with the aim to understand processes that determine the hesitant approach of women to engineering and to develop measures to change that situation.

The European CuWaT (1998) program focuses on developing pedagogical changes through involving teaching staff of tertiary education institutions of technology, engineering and computing. The results provide evidence that some changes are particularly effective for retaining women if courses become cross-disciplinary and involve significant elements of group work and project work. The situation of women in science, engineering and academia is covered with a wide range of research activities (Engler 1993; Ihsen 1996; Kosuch 1996; Roloff 1989; Schaare et al. 1993; Schneider/Schmelter 1995)².

2.2 Non-European Research on Women and Engineering

² Little research has been done investigating the situation of women in engineering professions (Bagilhole/Dainty/Neale 2000; Carter/Kirkup 1990; Erlemann 1997; Kvande 1999; for Non-European countries: Society for Canadian Women in Science and Technology 1999; Zuckerman 2001). Women project will focus on this issue in the second part.

More than 8000 male and female undergraduate engineering students from 29 institutions in the USA have been surveyed in the WEPAN Policy Climate Survey exploring the Environment for Undergraduate Engineering Students. The investigation of engineering students’ perceptions of the educational climate at colleges and universities serves to tinge engineering degrees, to explain the higher drop out rates of women engineering students, identify the factors that deter women from completing their degrees and to develop measures to increase their persistence rate. The WEPAN study suggests that feelings of isolation due to minority status may contribute to low self-esteem. One of the most powerful influences is the lack of self-confidence in intellectual abilities based on low self-esteem due to their minority status. Men are less affected by poor teaching, poor organisation of course material and by dull course content. US National Council for Research on Women report (Thorn 2000) has shown the importance of the first year for women having entered engineering in higher education. Since women tend to evolve an interest in technology over time, the ‘typical first-year ‘killer’ exams designed to weed out students rather than invite their participation may be contra productive for retaining female students.

Etzkowitz et al. “have found that ‘critical mass’ is meaningless when women are isolated and unknown to each other, when affiliation with other women is too stigmatising, or the female faculty model available reflects an archaic, male stereotype impossible to emulate or incorporate into a contemporary professional identity” (Etzkowitz et al. 2000: 245).

Australian research stress the significance of women working with men and of gaining sympathetic men as partners for social changing process. Jane Copeland, among others, in her work with colleagues from the Department of Electrical Engineering of the University of Adelaide indicates that “recognising the different skills, perspectives and learning styles that women bring to engineering and incorporating these into the teaching and learning environment“(Copeland 1995:18) means challenging the assumptions and practices within engineering itself.

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3 The survey is modelled after the “Quality of Engineering Education Survey” which since 1993 has been administered yearly to engineering students at the University of Washington (Brainard/Laurich-McIntyreCarlin 1996; Brainard/Carlin 1998; Brainard/Carlin 2001).

A joint research program of the Swinburne University of Technology and the University of Adelaide has shown the importance of integrating male teaching staff and students in developing gender-equal curricula (McLean et al. 1996, Lewis/Copeland 1999).

3 Design and Methodology for Measuring Organisational Cultures in Engineering Education

Organisational cultures of engineering in research are often blamed to discriminate female students by self-advertising, curriculum, teaching methods, social networks which marginalize female students etc. With a multi-methodological approach formal and informal characteristics will be measured with a special focus on masculinities.

3.1 Hypotheses

The following diagram shows in the part above the overall hypotheses about interdependencies, dimensions and operational aspects of educational cultures.

Diagram: Dimensions and Interdependencies of Engineering Organisational Culture

5 Cand. soc. Jennifer Dahmen made the diagram.
Formal and informal characteristics of departments, in which the engineering degree courses are organized are the object of investigation, like culture of: self-advertising of department/industry, curriculum, mono-educative studies, teaching and mentoring, studying conditions, sex equity coordination, social network, behaviour and showing power. For all these cultures subheadings were formulated which are hopefully so concrete, that they are open to observation, interviewing of representatives, discussion of focus groups with students. Some of them can be investigated by document respectively content analysis. There are objective ones like curriculum, compatibility of timetable or more subjective ones like personal style and care of teachers⁶.

3.2 Methodology

Womeng investigates national situations and cross cultural differences of masculinities by quantitative and qualitative methods. To get forward with the research issues first of all 2 standardised questionnaires for engineering students in comparison to non-engineering students were prepared and will be offered 100 female and 100 male students as control group in all 7 European partner countries. Sampling of degree courses will be oriented on the basis of lower, middle and higher percentage of female students depending on national statistics, choosing the most from degree courses with the lowest number. In the non engineering control group there will be 35% students in natural sciences 35 % in social and human sciences and 30 % in economics. As most of the questionnaire will concentrate on conditions for choosing engineering as degree course (workpackage 2), satisfaction and persistence (workpackage 3), there will be also a part on questioning about organisational culture in the departments of engineering. But mostly organisational cultures of engineering education will be investigated by different qualitative methods.

For complementary of quantitative questionnaires there will be about 20 guided interviews with students about their choice of degree course, experiences and satisfaction with study life, content, teaching methods and atmosphere and knowledge about reasons for drop out. In interviews students will tell us as individuals.

To get more to the level of group experience we will carry out 3 separate focus groups or group discussion with female students on three different issues: 1) self-projection of the faculties and their treatment towards the students, especially women students, 2) teaching and curriculum   

⁶ Presentation of the full list of items would be too much for this paper.
(experienced preferences, advantages and disadvantages) and 3) social network - integration, friendship and 'community' in the department. Interesting are here if the culture of telling masculine jokes is still existing. All groups should also refer to opinions and attitudes about self-advertising of the department and mono-education, the letter to get special perspectives for social change.

Complementary to female student groups focus groups with male students will discuss their motivation, opinions and attitudes on engineering image and female engineering students with special focus on equity and interdisciplinarity. Interests and hobbies for starting studies and political interests outside the department while studying should also be asked. Social life in the engineering department with stories and jokes will be an issue, to prove if this form of communication still exists and has a women excluding function, obvious or hidden.

Size of the groups should be up to 10 participants. The discussion should last up to 2 hours and be videotaped.

**Semi-structured expert interviews with high school representatives** will provide data of their perspectives about conditions and organisational necessities of studying and working in engineering and chances for social change. They should characterise their faculties as competitive, supportive, hierarchic, communicative, traditional, targeted and tell if they believe it will be more supportive for men or for women. Special welcome activities for new students will be asked and if there exists a kind of informal "bullying" for new students. Teaching methods, system and organisation of advice and mentoring and practical experiences with gender differences are of interest. Last not least representatives will be questioned about special advertising of their department/faculty as there are communication campaign, special booklets, presence in some specific events in different cities/schools, in order to bring information about engineering to high schools’ students or students in other faculties. The interviews will be taped and transcribed afterwards. They will be interpreted first on the national level and than be compared cross cultural.

Data from **participant observations** of co-operative structures and teaching styles (frontal lessons, teamwork, projects) in studying and laboratory situations in traditional engineering faculties and those with innovative degree courses will help to determine the impact of the latter. Lectures of different subjects should be chosen for observation (subjects having a strong image and subjects having a soft image). Observed lectures should be given by men and by women. Besides visual characteristics of department and gender/diversity special information on boards etc. can be observed by visiting engineering departments. Observation can't be seen as a method which is limited to 'seeing', of course it's also 'hearing', 'feeling', 'talking' and 'reading'. Even though participant observation (overt and covert) is not the most reliable research method, it offers the possibility to study a process in action and it is easier to take note of non-verbal behaviour of the people being observed. This method hopefully can complement information gained by the other methods.
Document analysis of internet pages, flyers, prospects, statistics, internal faculty and company papers give information about accompanying measures for furthering women in engineering education.

The website analysis is guided by a criteria catalogue which guides the observer through the website. Because websites are a combination of text and pictures there can be found a lot of information in them. We want to find information on integrated internships, welcome meetings, mentoring-, equal opportunity-, gender mainstreaming-, diversity-programs, life long learning possibilities and re-entry programs.

Sampling for all these methods will be decided on basis of the selected institutions of higher education for standardised questionnaires. So results can be compared and complement each other.

All data will be gathered in the participating countries and will be interpreted first in the national context. Second to prove transferability in European countries external and internal organisational conditions will be compared, especially in consortium countries (cross cultural analysis).

Some information is easily to get, other especially discriminating characteristics often are hard to get. For example “willingness of verbal account” with jokes and stories as team characteristic – often told about in literature – perhaps will not be openly talked about, because it is not political correct in most European countries at the moment.

Interesting is the comparison with Slovakia as Central European country with traditionally high rates of female engineering students. Differences between Slovakia and EU countries could be interpreted by a different cultural and historical background (communist experience of the 45 years, higher religiosity, shorter industrial history, stronger tradition, etc.).

In looking for best practice a special focus lies on single sex education models in engineering (as in Germany and non-European countries as USA). Information about selected examples of good practice from other non-European countries and transfer to European situations will be gathered by literature analysis and expert interviews. Especially North America and Australia seem to have good practice in co-operational structures between institutions of higher education and international companies and more developed equal opportunity and diversity (ethnic, class, age, gender, nationality) programs.

All results will serve as a basis for developing a set of recommendations.

4 Theoretical Reflections on Masculinity in Organisational Cultures of Engineering Education
Even though reality has changed both in engineering and in gender the stereotypes are still alive and they are still influential as most women do not choose engineering as degree courses so long as it seems to be unchanged a men’s field. Under the focus of organisational cultures the female socialisation process as most often explanation for the small number of women in engineering can be ignored. The initiatives based on this theory started to compensate girls’ assumed deficits in the technical field, but these measures (information days or weeks and mentoring in all stages of decision for female students only) could not change organisational structures.

4.1 Engineering and Gender as Results of Social Construction of Segregation

In contrast to the normative way of feminist thinking based on gender differences feminist perspective changed to construction of gender and gender segregation manifested in social order, of which social structure of exclusion is one characteristic.

Engineering can be considered as gendered in three ways. First, gendered structures are visible in gender difference in the division of labour and in the work styles of women and men. Second, the symbols and images of engineering knowledge and practice (artefacts, institutions) are gendered through cultural associations between masculinity and technology. And third, individual engineers have gendered personal and professional identities and experiences (Faulkner 2000; Harding 1986).

Central to engineering is a faith in cause-and-effect, a perception that Mellström (1995) has called ‘binary thinking’. Popular images of science and technology have strong connotations with the masculine sides of dualisms such as hard : soft, abstract : concrete, people-centred : technology-centred, mind : body, rationality : emotionality. “Sexual ideologies and stereotypes are diverse and fluid, but such opposites as ‘male/female’ and ‘reason/emotion’ are central to Western culture. The notion that women are closer to nature than men contains various elements such as that women are more emotional, less analytical and weaker than men. In the advanced industrial world, where scientific and technical rationality are highly valued, these associations play a powerful role in the ideological construction of women as inferior” (Wajcman 1991, 1996: 145).

On the other hand this may be one reason why there are at least some engineers who seek refuge from human relationships in mathematics or technology (Faulkner 2000; Håpnes 1996; Mellström 1995).

Whenever (young) women enter a “male domain”, be it as science or engineering student or professor at a Technical College or University or as engineer in a company, they encounter similar mechanisms due to their minority status. Ongoing practice of “doing gender” (West/ Zimmerman 1991:13-37) enforces these experience of “otherism”. Historically grown and culturally attributed values, connotations and prejudices that, in our case, link technological competence with masculinity (McLewis et al. 1996:6) are extremely persistent and change only very slowly.
4.2 Social Construction of Masculinity and Engineering

The feminist perspective of women’s and gender studies go along with critical men’s studies’ perspective (Connell 1999, Hearn 2002, Höyng/Puchert 1998, Meuser 1998). Bob Connell sees the so-called ‘hegemonic masculinity’ as central. It is achieved by the organisation of private life and cultural processes, and it is a special of the rational middle class men (Connell 1999) or of the functional elite (Meuser 1998), who will not see any need for self-reflection or social change, if not pushed by women. Even though analysis has shown different groups of men by orientation, life style and potential for social change to equity – skilled worker with or without labour, alternatively engaged men, homosexual men (Connell 1999) - they always get the “patriarchal dividend” (Connell 1999) from networking.

The bond between hegemonic masculinity and engineering lies in the social construction of engineering as masculine issue in the polarisation female-male. In the advanced industrial world, where scientific and technical rationality are highly valued, these associations that women are more emotional, less analytical and weaker than men, play a powerful role in the ideological construction of women as inferior (Connell 1999).

In research literature the masculine atmosphere is blamed to hinder women from retaining and finishing their engineering study or to feel not “at home”, leaving after the exams, making no efforts for a planned career in the field. Women’s ‘invisibility’ within engineering, not only because of their absence as staff and students but also in terms of any recognition of their contribution to the history of technology must be changed for providing a suitable study environment at higher education institutions. So it is not the “hard” science subject which explains withdrawal of female students – they normally succeed in these subjects likewise as male students, but the felt women excluding atmosphere. Elements of this dominant masculinity (Connell 1999) are male fraternities by stories, jokes, leisure sports and similar informal strategies all constructed explicitly or implicitly for exclusion of women – conscious or/and unconscious (Faulkner 2000; McLean et al. 1996).

4.3 Women’s Marginalizing Process in Technology

Even though exclusion of women by gender segregation can be interpreted on a macro societal level, feelings of being excluded could be a source for deeper insecurity feelings with a negative influence on self-confidence. Self-confidence is the most prominent single factor for success especially in male dominated fields, in study and professional life.

Wajcman sees women’s marginalizing in technology constructed in the following ways. After childhood the stereotypes of male competence and female distance to technology are created in puberty and “the absence of technical confidence or competence does indeed become part of feminine gender identity, as well as being a sexual stereotype” (Wajcman 1991, 1996). The construction of gender differences continues as “Males are portrayed as fascinated with the machine itself, ‘being’
Females are described as only interested in computers as tools…” (Wajcman 1991, 1996). This is similar to Erb’s main outcome that women’s distance to technique comes from their narrow definition of technique (Erb 1996). And, defining themselves as less technical competent reduces their self-confidence. In computer work women tend to see their part always as less valuable and at the same time they do not want to take over the social constructed habitus as computer freak, which seems for most of them not combinable with their image of femininity, but at the same time higher valued (Håpnes /Rasmussen 1991).

4.4 Fighting against Gender Stereotypes – Changing Masculinity Cultures

Enduring gender and engineering stereotypes with sets of dualism influence our thinking fundamentally. Two central elements for fighting against gender and engineering stereotypes are interdisciplinarity and mono-education. Both can be interpreted as approaches to weaken gender segregation. If non-technical contents meet the interests of female students the degree course will be more attractive, and by this way the gender gap in engineering can hopefully be decreased. With non-technical subjects in engineering degree courses masculinity cultures in engineering departments could be changed by contents - female fields of interest and competence-, diversity of students and staff and new competences of engineers students get during their studies. Interdisciplinarity could include a complementary or/and a critical element, higher education staff seem to hesitate to change the status quo. When interviewing representatives from universities with traditional degree courses in INDECS barriers were seen in full schedules for students with technical subjects, which all seemed to be necessary. So there was hardly seen any space for non-technical subjects.

To put in non-technical contents in degree courses means to put some technical knowledge in later life phases to learn, by life long learning, in which all professionals are expected to engage in. So it will be less stigmatising to have short breaks in the career for both gender.

As a quasi ‘paradox intervention’ (Gransee 2000) mono-education of female students hypothetically can deconstruct gender differences. Instead of these those differences between female students are allowed to become visible, and the significance of co-educational environments on female students’ self-confidence is high. And, because of the crucial self-confidence for a career in a male dominated world, one can expect that mono-educational possibilities could help to overcome the inner and outer barriers. There is a different political agenda in European partner countries on the estimation of mono-education. In Germany in the course of feminist research and discussion about co-education in the last years several so called mono-educational models were installed in engineering degree courses – like the one in Wilhelmshaven and Bremen (Siegle 2000; Vierkandt 2002) we investigated.

Interdisciplinarity in engineering degree courses as measure to increase the rate of female students has been the main focus of the European research project INDECS which has been finished 2002 by the same partner countries as in Womeng.
in INDECS. Universities’ representatives at management level seem to be the most prominent barrier against institutionalisation of mono-educational elements. Moreover in France and UK there seems to exist no actual positive discussion of mono-education. At the same time in non European countries like the US or South Korea women colleges are flourishing. So the main contra argument of self-stigmatising by separated educational rooms seems weakened.

5 Conclusions

Several problems of the project’s part “cultures of engineering faculties” remain at the moment. First, will it be possible to get access to the department, lectures and situations, which are discriminating or helpful for young female engineering students on their way through the educational system – getting in, retaining, getting influence, networking with cooperative men -? Second, will the empirical research be successful in making the often invisible masculine culture visible? How optimistic can we be in relation to social change? The social construction perspective is possibly short cut, devaluing different power and interest of powerful men who do not want to give up part of it and make change happen.

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